

# EdGCM: Educational Global Climate Modeling



## Tools for Training the Climate Change Generation

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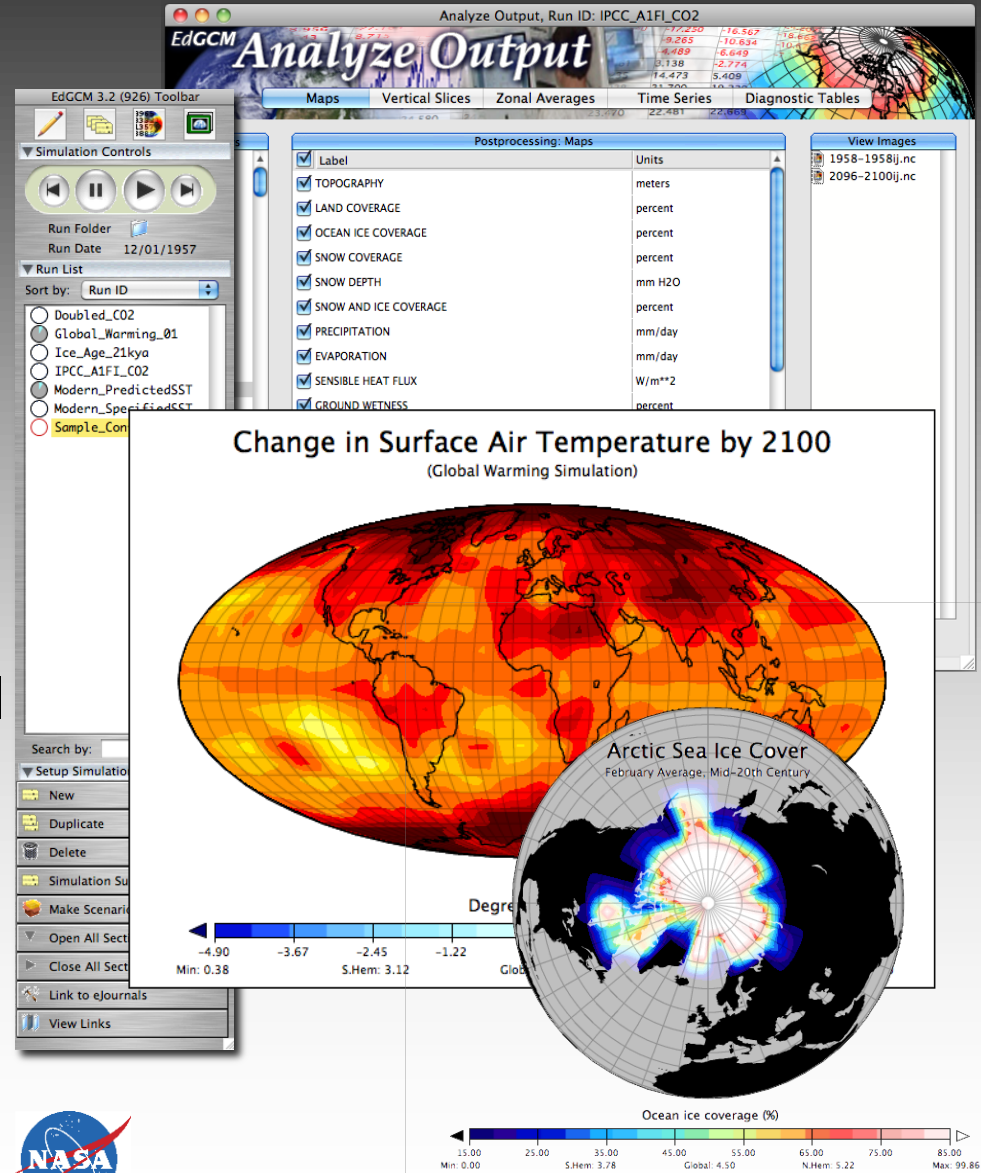


# Educational Global Climate Modeling

*The world is in your hands.*



- Run a real NASA climate model
- Create your own simulations
- Make maps and plots
- Hundreds of climate variables
- Past or Future climates
- Mac or PC
- <http://edgcm.columbia.edu>



# The Educational Global Climate Modeling Project



## Project Objectives

- Allow teachers and students to use a genuine research version of NASA global climate model on accessible computers (desktop and laptop)
- Encourage students to participate in the full scientific process
  - Design experiments
  - Setup and run computer simulations
  - Analyze data
  - Communicate results

# The Educational Global Climate Modeling Project



## Project Objectives

- Enhance collaborations between schools, universities, national labs, and the private sector so students become familiar with the role of teamwork in scientific research.
- ...and by doing the above demystify how scientists forecast climate change.





Seinfeld's Diner

# Future Climate Change: Basis of Understanding



James Hansen, 1988

1. **Earth's Climate History**
2. **On-Going Global Changes**

# On-Going Global Change: Coming Soon to a Community Near You



# Future Climate Change: Basis of Understanding



James Hansen, 1988

1. Earth's Climate History
2. On-Going Global Changes
3. **Global Climate Models**  
(note: modeling #3, but aids other two)



# Climate Change Intelligence

GCMs are the primary tools used to supply climate change forecasts. They help us study the physical processes of climate change, predict its impacts, and evaluate mitigation and adaptation strategies.

# Global Climate Model

Atmosphere



Oceans



Cryosphere



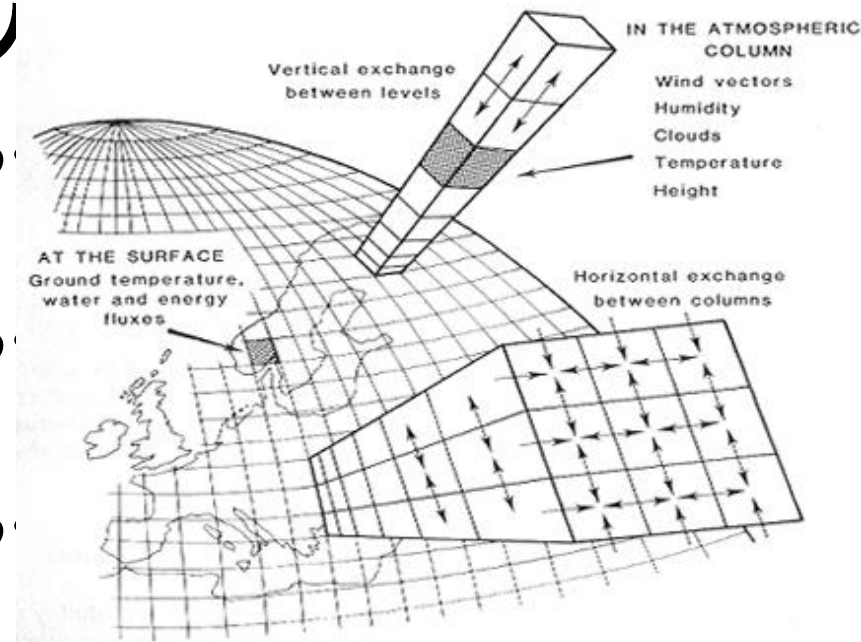
Land Surface



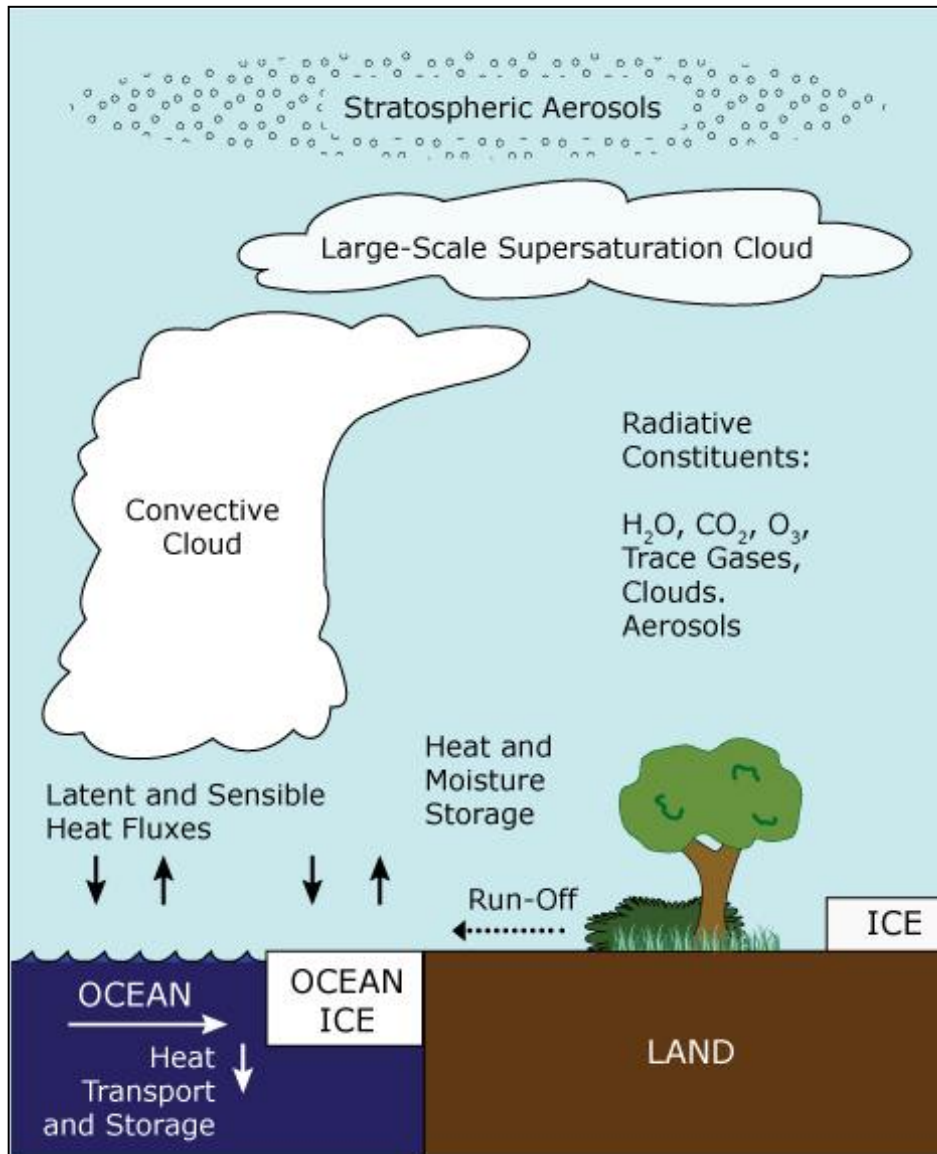


# Tools of the Trade: Global Climate Models

- 這是“質量守恆定律”，在中國
- 這是“節約能源”
- 這是“動量守恆”
- 這是“保護水分”
- 這是“狀態方程”寫在中國



# Physical Processes Simulated by GCMs



- Seasonal and Diurnal Cycles
- Latent and Sensible Heat Fluxes
- Clouds and Convection
- Greenhouse Gases
  - snow
- Aerosols
- Ground Hydrology
  - soil moisture, run-off
- Ocean Heat Storage & Transport
- Ocean Circulation
- Atmospheric Chemistry
- Carbon Cycle
- Dynamic Vegetation
- Dynamic Ice Sheets



GCMs were predicted to be in common  
use by now...

“...Very soon it will be possible to run a GCM on a laptop  
computer.”

“GCMs will begin running on workstations in high  
schools, and possibly elementary schools. They may even  
be running in the offices of congressman.”

Dr. David Randall

Bulletin of the American Meteorological Society, 1996

...but there were stumbling blocks

# What is a GCM?

# ...a computer program

Global\_Warming\_Sim2.R Model II 8/24/2000

Owner: Mark Chandler, m.chandler@nasa.gov

Group: Paleoclimate Group

This experiment simulates the climate of the snowball earth period of the Neoproterozoic Period in geologic history.

Object modules:

MainC9 DiagC9 RadC9

```
C** INITIALIZE SOME ARRAYS AT THE BEGINNING OF SPECIFIED DAYS
```

```
fName = './prt'/'JMINTH0(1:3)'/CYEAR/'./prt'/'LABEL1(
```

```
IF(JDAY.NE.32) GO TO 294
```

```
JEQ=1+JM/2
```

```
DO 292 J=JEQ,JM
```

```
DO 292 I=1,IM
```

```
292 TSFREQ(I,J,1)=JDAY
```

```
JEQM1=JEQ-1
```

## How does one learn to use a GCM?

23=V8X10\_600Ma

26=Z8X101\_600Ma

21=RTAU.G25L15

22=RPLK25

29=Snowball\_Earth\_Regions

Label and Namelist:

Global\_Warming\_Sim2 (Transient increase in CO2)

&INPUTZ

TAUI=10176.,IYEAR=1900,

KOCEAN=1, SRCOR=.95485638151,

S0X=1.,CO2=.31746031746031,

USET=0.,TAUE=35040.,USESLP=-12.,

ISTART=3,KCOPY=2,NDPRNT=-1,TAUE=95616.

```
295 TSFREQ(I,J,1)=JDAY
```

```
C**** INITIALIZE SOME ARRAYS AT THE BEGINNING OF EACH DAY
```

```
296 DO 297 J=1,JM
```

```
DO 297 I=1,IM
```

```
TDIURN(I,J,1)=1000.
```

```
TDIURN(I,J,2)=-1000.
```

```
TDIURN(I,J,6)=-1000.
```

```
PEARTH=FDATA(I,J,2)*(1.-FDATA(I,J,3))
```

```
IF(PEARTH.GT.0.) GO TO 297
```

```
TSFREQ(I,J,1)=365.
```

```
TSFREQ(I,J,2)=365.
```

```
297 CONTINUE
```

Unix Scripts

Fortran Code

# Computing Resources and Climate Models

Rule of thumb:  
10X more CPU  
doubling of  
on

$8^{\circ} \times 10^{\circ}$

IPCC

$4^{\circ} \times 5^{\circ}$

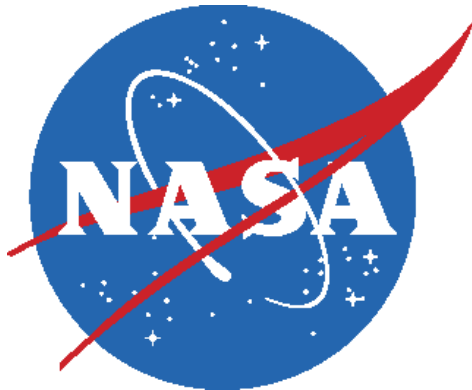


2001, 2007  
IPCC AR3, AR4

2014  
IPCC AR5

# What is *EdGCM*?

- A GLOBAL CLIMATE MODEL  
The NASA/GISS GCM Model II
- A GRAPHICAL USER INTERFACE  
Wrapped around the global climate model



NASA Goddard Institute for Space Studies  
Global Climate Modeling Program  
[www.giss.nasa.gov](http://www.giss.nasa.gov)



Columbia University, EdGCM Project  
Center for Climate Systems Research  
[edgcm.columbia.edu](http://edgcm.columbia.edu)



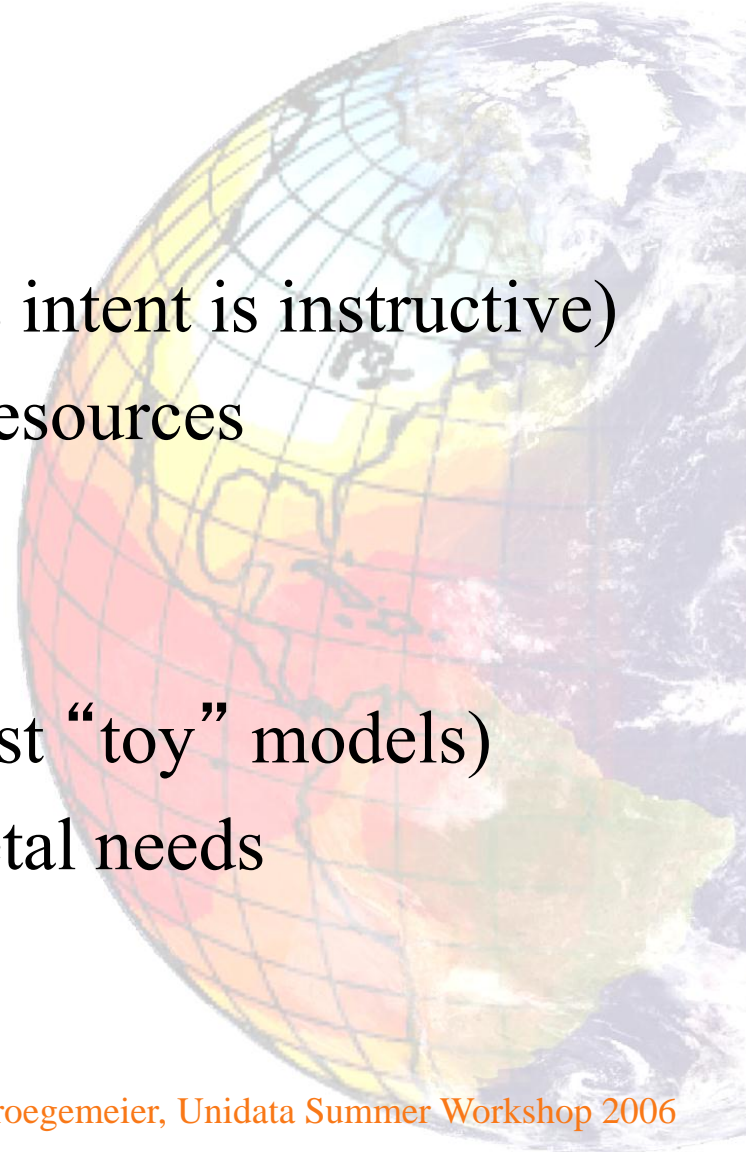
# Other Computer Code Wrappers



# Democratization of Global Climate Modeling

Tools for non-specialists must be:

- ▶ Highly intuitive
- ▶ Free of jargon (except where its intent is instructive)
- ▶ Usable on existing computing resources
- ▶ Free (or at least inexpensive)
- ▶ Responsive support
- ▶ Applicable to real world (not just “toy” models)
- ▶ Tied to current events and societal needs





# Set up, Run and Organize a GCM

The image displays a collage of the EdGCM 3.2 (926) software interface, illustrating the workflow for setting up, running, and organizing a General Circulation Model (GCM) simulation.

**EdGCM 3.2 (926) Toolbar:** The top-left window shows the main toolbar with simulation controls (play, pause, stop, reset) and a run list. The run list includes scenarios like Doubled\_CO2, Global\_Warming\_01, Ice\_Age\_21kya, IPCC\_A1FI\_CO2, Modern\_PredictedSST, Modern\_SpecifiedSST, and Sample\_Control\_Run.

**Setup Simulation, Run ID: Global\_Warming\_01:** The central window shows the setup for a specific simulation. It includes a general info section with project ID, run label, and comments. Below this are sections for input files, ocean model, diagnostic output, and forcings (Greenhouse gases, Solar, Orbit, CO2 trend, N2O trend).

**Simulation Library:** A window showing a table of available simulations:

Run ID	Label	Date	Owner
Doubled_CO2	Global Warming from doubling CO2 instantaneously	02/11/05	Mark Chandler
Global_Warming_01	Global Warming: CO2 gradually increases, doubling by 2069	02/11/05	Mark Chandler
Ice_Age_21kya	Ice Age 21kya, LGM trace gases, modern orbit	02/11/05	Mark Chandler
IPCC_A1FI_CO2	Global Warming: IPCC illustrative scenario A1FI	06/08/09	Linda Sohl
Modern_PredictedSST	Modern Control Run, 1958 forcings with predicted SSTs	02/11/05	Mark Chandler
Modern_SpecifiedSST	Modern Control Run, 1958 forcings with Specified SSTs	02/11/05	Mark Chandler
Sample_Control_Run	Modern control run for Model II v1.0.6 8x10 qlux	05/14/05	Mark Chandler

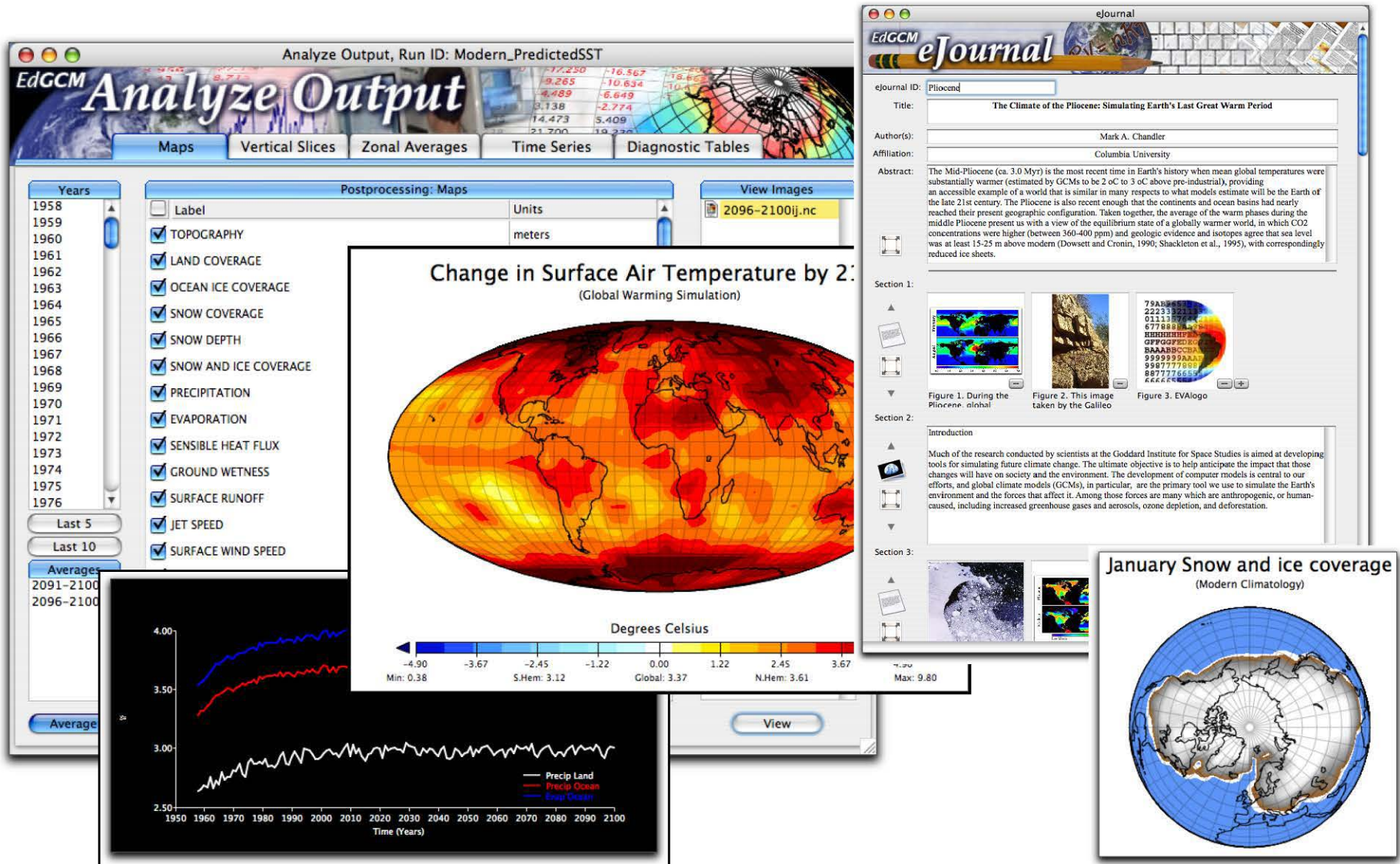
**Cleanup:** A window showing run statistics and disk space usage for selected runs (e.g., IPCC\_A1FI\_CO2). It includes sections for Run statistics (Current used, ACC, Diagnostics, Ocean, PRT, RSF) and Disk statistics (Disk space, Volume, Capacity, Current used, Available).

**EdGCM 4D:** A window showing a 4D visualization of the Earth's surface, likely representing a simulation result.

**Image Browser:** A window displaying a series of images related to the simulation, such as maps of annual average surface air temperature, continent-scale ice sheets, and difference maps.

**EdGCM: Ocean Fluxes:** A window showing ocean fluxes and a timeline of simulation results. It includes sections for Vertical Fluxes, Mixed-layer Temperatures, Ocean Heat Transports, and a timeline of simulation results (Start year, End year, RSF year).

# Analyze, Visualize and Publish Results





# Creating Reports and Publishing

## eJournals

**eJournal**

EdGCM

eJournal ID: Pliocend

**The Climate of the Pliocene: Simulating Earth's Last Great Warm Period**

Mark A. Chandler  
Columbia University

**Abstract:** The Mid-Pliocene (ca. 3.0 Myr) is the most recent time in Earth's history when mean global temperatures were substantially warmer (estimated by GCMs to be 2 oC to 3 oC above pre-industrial), providing an accessible example of a world that is similar in many respects to what models estimate will be the Earth of the late 21st century. The Pliocene is also recent enough that the continents and ocean basins had nearly reached their present geographic configuration. Taken together, the average of the warm middle Pliocene presents us with a view of the equilibrium state of a globally warmer world, in which CO<sub>2</sub> concentrations were higher (between 360-400 ppm) and geologic evidence and isotopes agree that sea level was at least 15-25 m above modern (Dowsett and Cronin, 1990; Shackleton et al., 1995), with correspondingly reduced ice sheets.

**Section 1:**

Figure 1. During the Pliocene, global temperatures, particularly at high latitudes, are believed to have been significantly warmer than today. This figure

Figure 2. This image taken by the Galileo

Figure 3. EVAlogo

**Section 2:**

**Introduction**

Much of the research conducted by scientists at the Goddard Institute for Space Studies is aimed at developing tools for simulating future climate change. The ultimate objective is to help anticipate the impact that those changes will have on society and the environment. The development of computer models is central to our efforts, and global climate models (GCMs), in particular, are the primary tool we use to simulate the Earth's environment and the forces that affect it. Among those forces are many which are anthropogenic, or human-caused, including increased greenhouse gases and aerosols, ozone depletion, and deforestation.

**Section 3:**

## Image Libraries

**Image Browser: Images 1-16 of 19 images**

View: Snowball Earth

Map of annual average surface air temperature

Continent-scale ice sheets have tremendous

This graph shows the increase in the Sun's

Difference map showing the deviation of annual

Map of annual average surface air temperature

Map of annual average snow and ice cover for

Timeline of some key events and intervals in

Advanced radar imaging of sea ice cover in the

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**Figure 1:** During the Pliocene, global temperatures, particularly at high latitudes, are believed to have been significantly warmer than today. This figure

**Figure 2:** Cap Carbonates overlying glacial diamictite.

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## Web-based Publishing

# The EdGCM Websites

Spotlight on...



EdGCM provides a research-grade model that can be run on a desktop computer. For the same way that actual research is done, you can become knowledgeable about a topic that interests you, or the next generation of scientists who will grow up to solve the world's problems.

Our goal is to improve the quality of climate science, and to provide access to GCMs, and to provide

### EdGCM Forums

Forum	Topic	Author	Date	Replies	Views
Announcements	EdGCM goes to Antarctica	mankoff	July 13th, 2007 21:45	24	38
	Changed permissions/flags...	mchandler	Today 10:26	53	349
	Why does the SLP in EdGCM's...	Patrick LEE	October 6th, 2007 00:31	52	385
Technical Support	Reinstalling or Updating EVA...	mchandler	October 3rd, 2007 23:25	14	74
	EdGCM Icon	mchandler	April 2nd, 2006 14:06	7	33
	Dirt snow	mchandler	June 20th, 2007 11:07	5	80
Science and Modeling Questions	EdGCM in Italy	mchandler	December 4th, 2006 20:06	6	8

- Download Software and Materials
- Support and Discussion Forums
- Community and Student Showcases
- Video Tutorials and Manuals

# Education Partnerships



University of Wisconsin – Madison  
Department of Atmospheric and Oceanic Sciences  
Geography Department



Southern University (and LSU) – Baton Rouge, LA  
Urban Forestry Program



Dickinson College  
Community College Teacher Professional Development



American Museum of Natural History  
Seminars in Science, Continuing Education Programs



Columbia University, New York, NY  
 University of Wisconsin - Madison  
 Rutgers University, Newark, NJ

Macalester College, St. Paul, MN  
 Clarkson University, Potsdam, NY  
 Indiana University Southeast, New

Madison East High School, M  
 Memorial High School, Madi  
 Youngstown State University,

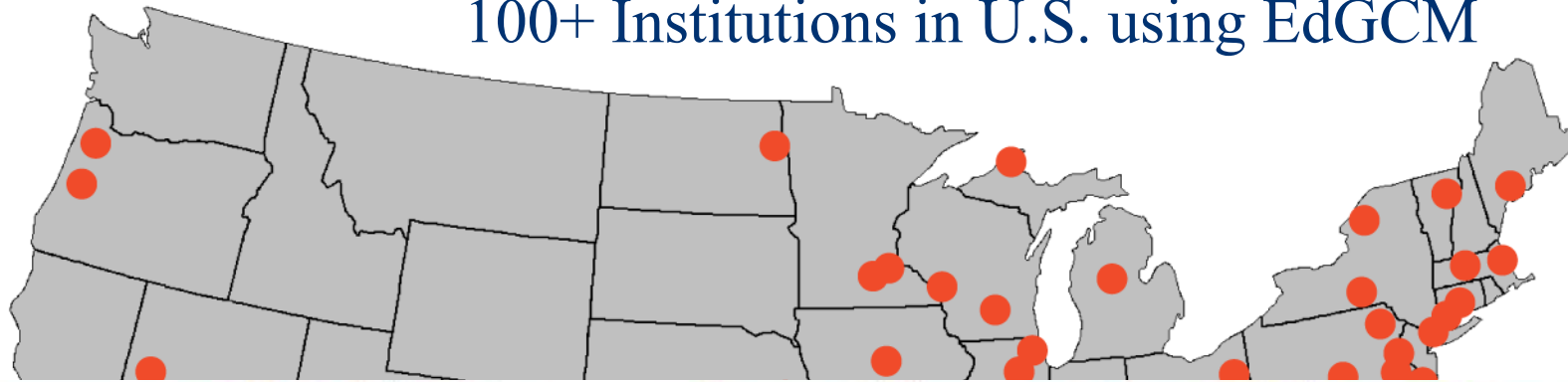
City O  
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 Univer  
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## 100+ Institutions in U.S. using EdGCM



Pleasant, MI

University of California - Riverside,

University of Massachusetts -



# Global Interest. Global Need.

- 
- A world map with a blue background and green landmasses. Numerous red diamond-shaped markers are scattered across the map, indicating global locations. There is a high concentration of markers in North America, Europe, and East Asia, with more sparse distributions in South America, Africa, and Australia. A semi-transparent dark blue rectangle is overlaid on the map, containing a bulleted list.
- Used in student science competitions
  - Used in research for those having no access to supercomputers or scientific programming staff

# Challenges

Keeping up with the pace of cutting edge climate modeling and consumer electronics companies

- Windows 7 and Windows 8
- Mac OS X Lion & Mountain Lion
- EzGCM and WebGCM
- iOS and Android – tablet computing in schools



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